Comparison of Magnetic Barkhausen Noise Tetrapole and Dipole Probe Designs

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Abstract

Introduction

Magnetic Barkhausen Noise (MBN) [-] arises from the abrupt motion of domain walls in ferromagnetic materials under changing magnetic fields. MBN is influenced by several factors including the stress state of the material [1]. The original work done on the directional dependence of MBN production used dipole probes, which had to be manually rotated [2]. This was a slow procedure. Tetrapole designs (Figure 1) seek to overcome this by using two orthogonal dipoles and the principle of superposition to rotate the applied field without rotating the probe [3-5]. It was found, however, that the directional dependence of the MBN produced by electronically rotating the field with a tetrapole was significantly different from that produced by physically rotating the dipole.

Use of Comsol MultiPhysics

The Magnetic fields interface within the AC/DC Module of COMSOL Multiphysics® software was used to model the tetrapole and dipole fields using a frequency analysis. Modelling of the laminar Supermendur magnetic cores required implementing directional conductivity matrices. Modelling of the magnetic anisotropy of the steel substrate required modelling the permeability with a full matrix and BH curves.

Results

Figure 2 shows the field induced in the sample when the tetrapole is operated at 0° , which causes the field to align with a pole pair and the line of maximum permeability. The field produced is very similar to what would be produced by a dipole probe i.e. the field aligns with the direction of maximum magnetic flux through the sample.

Figure 3 shows the field when the tetrapole is operated to produce a field at 45° to the poles. In this case the field has rotated one way, but the line of maximum flux intensity has rotated the other way. This configuration is not possible with a dipole probe.

Conclusions

COMSOL modelling of the interaction of a tetrapole Magnetic Barkhausen Noise probe demonstrated that more than simple superposition of fields was taking place in the sample and that for the tetrapole the field was being rotated in one direction, while the line of maximum field intensity was being rotated in the opposite direction.

Reference

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2 T. W. Krause, L. Clapham and D. L. Atherton, “Characterization of the magnetic easy axis in pipeline steel using magnetic Barkhausen noise.” J. Appl. Phys. 75, (1994) 7983-7988.

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4 S. White, L. Clapham and T.W. Krause, “A multi-channel magnetic flux controller for periodic magnetizing conditions.” IEEE Trans. Instr. and Meas. 61, no. 7, (2012) pp. 1896-1907.

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Figures used in the abstract

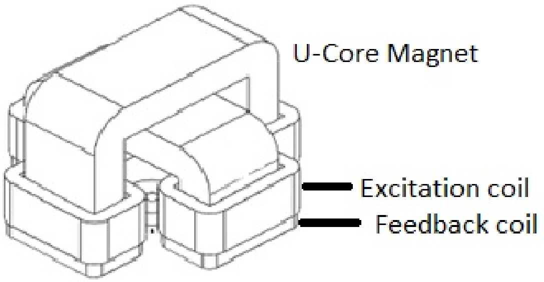

Figure 1: Figure 1: Tetrapole probe [3]

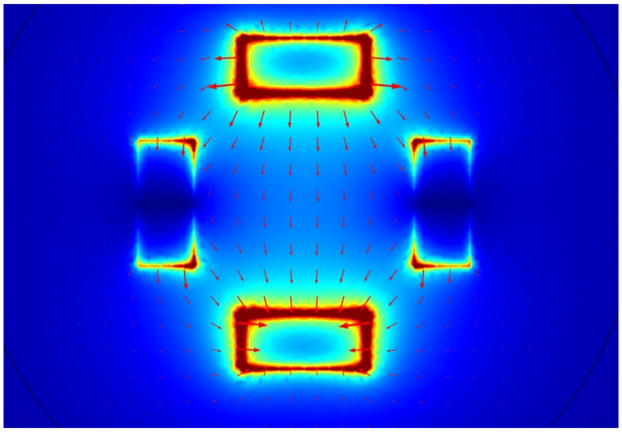

Figure 2: Figure 2: Magnetic field in substrate due to a tetrapole operating at 0° angle. Arrows indicate direction of magnetic field. Colours (blue to red) indicate increasing magnetic flux density.

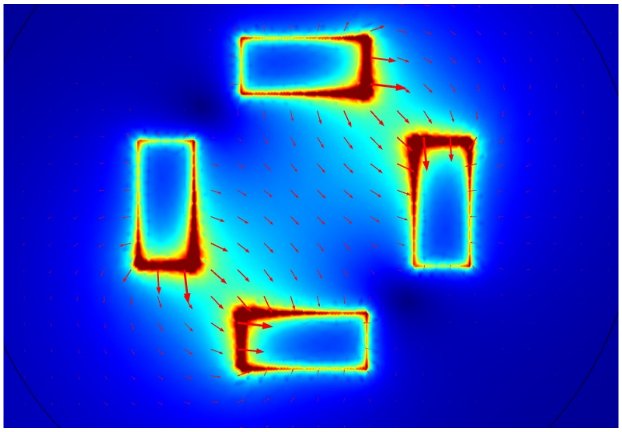

Figure 3: Figure 3: Magnetic field in substrate due to tetrapole operating at 45° angle. Arrows indicate direction of magnetic field. Colours (blue to red) indicate increasing magnetic flux norm.

Figure 4